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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : H04Q 7/32 | A1

(11) International Publication Number: WO 00/36861

(43) International Publication Date: 22 June 2000 (22.06.00)

(21) International Application Number: PCT/SE99/02215

(22) International Filing Date: 29 November 1999 (29.11.99)

(30) Priority Data:
9804420-9 17 December 1998 (17.12.98) SE

(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (publ) [SE/SE]; S-126 25 Stockholm (SE).

(72) Inventor: KÜNKEL, Lars, Peter; Hagensvägen 16, S-261 93 Landskrona (SE).

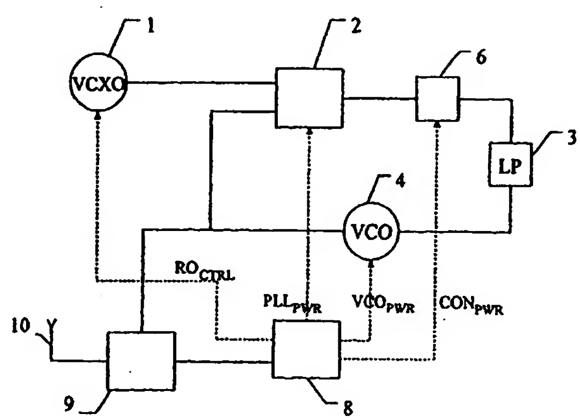
(74) Agent: HOFMAN-BANG A/S; Hans Bekkevolds Allé 7, DK-2900 Hellerup (DK).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: A METHOD OF REDUCING THE POWER CONSUMPTION OF PORTABLE RADIO COMMUNICATION SYSTEMS IN STANDBY MODE, AND A MOBILE STATION ADAPTED TO REDUCE THE POWER CONSUMPTION IN STANDBY MODE



(57) Abstract

The invention relates to a mobile station in a radio communications system having at least one base station serving one or more mobile stations, a method of reducing standby power consumption of said mobile stations, said method comprising the steps of: receiving messages in a mobile station from said at least one base station, said message comprising blocks of information bits; generating a check indication specifying the need for receiving some of said blocks of information bits; and turning-off co-operating portions of said mobile station defining periods of full power saving where blocks of information bits are omitted, said periods of full power saving being separated by periods of normal power consumption where some of said blocks of information bits are received. At least some of said periods of normal power consumption are replaced by periods of reduced power consumption where at least one of said portions is off. The invention further relates to a mobile station adapted to reduce the power consumption in standby mode in order to increase the possible time of operation during standby mode.

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A method of reducing the power consumption of portable radio communication systems in standby mode, and a mobile station adapted to reduce the power consumption in standby mode

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The present invention relates to a method of reducing the power consumption of radio communication systems, such as mobile telephones, in standby mode in order to increase the possible time of operation during standby mode.

Portable radio communication systems, also called mobile stations and mobile phones, may be operated in standby mode in which the mobile station continuously must receive and monitor signalling data sent by a base station. Mobile stations are often operated on battery power, and in order to reduce the frequency of battery charges and recharges, it is advantageous to construct and operate the mobile station in a manner which reduces the power consumption as much as possible.

According to the prior art, mobile stations are adapted to receive messages comprising blocks of information bits from at least one base station. A check indication is generated in order to specify the need for receiving some of said blocks of information bits. In order to reduce the power consumption, blocks of information bits are omitted by turning off co-operating portions of said mobile station, and hereby defining periods of full power saving. The periods of full power saving are separated by periods of normal power consumption where some of said blocks of information bits are received.

US patent 5,402,446 to Minami discloses a frequency-shift keying (FSK) receiver which is capable of reducing a consumption current due to a phase-locked-loop control. The

phase locked loop (PLL) is operative in some periods while non-operative in other periods. In the operative periods both a voltage controlled oscillator (VCO) and a phase locked loop circuit are on. The PLL-circuit and the VCO are turned on prior to the actual use in order to bring the voltage controlled oscillator into a normal oscillation state. In order to save power, the phase locked loop is turned off before the end of each period of operation.

The object of the invention is to provide a method of improving power saving compared to the prior art.

The invention thus relates to radio communications system having at least one base station serving one or more mobile stations, a method of reducing standby power consumption of said mobile stations, said method comprising the steps of: receiving messages in a mobile station from said at least one base station, said message comprising blocks of information bits; generating a check indication specifying the need for receiving some of said blocks of information bits; and turning-off co-operating portions of said mobile station defining periods of full power saving where blocks of information bits are omitted, said periods of full power saving being separated by periods of normal power consumption where some of said blocks of information bits are received, wherein at least some of said periods of normal power consumption are replaced by periods of reduced power consumption where at least one of said portions is off.

Hereby a reduction of the power consumption is obtained due to the fact that the power consumption during the periods of reduced power consumption (PRPC) is lower than the power consumption during the periods of normal power

consumption (PNPC). The power saving is significant as a large number of periods typically can be replaced.

In accordance with a preferred embodiment, said omitted blocks of information bits are redundant blocks of information. This is advantageous as reduced power consumption is achieved by omitting these data blocks containing data already received.

Preferably, said omitted blocks of information bits are blocks related to previously received blocks, said previously received blocks having been found to be irrelevant. Hereby, a reduction of the power consumption is achieved by omitting irrelevant data.

In a particularly expedient embodiment, a number of succeeding check indications are generated with predetermined intervening periods. This is advantageous as the power consumption is reduced in a simple manner.

In a preferred embodiment, said check indication is generated when an error has been detected in said blocks of received information bits. Hereby, an optimal power reduction is obtained even when data contains errors.

In a preferred embodiment, said co-operating portions include a voltage-controlled oscillator, a loop-filter, and phase detector means, where said voltage-controlled oscillator, said loop-filter, and said phase detector means being connected to form a phase-locked loop, and said phase detector means is turned off in said periods of reduced power consumption. Hereby, an additional reduction of the power consumption is obtained due to the fact that the time needed to start the VCO, i.e. bring the VCO into a desired oscillation state, is significantly shorter than the time needed to bring the phase locked loop into

lock. Hereby, a significant reduction of the power consumption is obtained in the long run when a number of periods are replaced.

Preferably, said phase detector means is turned off prior to the end of said period of normal power consumption. Hereby, an even further power reduction is obtained.

In a particularly expedient embodiment, a phase detector means is operated to have a high-impedance output port when said phase detector means is off.

In a preferred embodiment, a switch is operated in order to disconnect the loop-filter from the phase detector means during the periods of reduced power consumption.

In accordance with a preferred embodiment, the periods of normal power consumption to be replaced by periods of reduced power consumption are predetermined. Hereby, the power consumption is reduced in a simple manner.

In a preferred embodiment the periods of normal power consumption to be replaced by periods of reduced power consumption are determined by use of an automatic frequency control. Hereby, an optimal power reduction is obtained, i.e. periods of normal power consumption are only replaced by periods of reduced power consumption when needed.

The present invention also relates to a mobile station adapted to be used in a radio communications system, said mobile station comprising: receiver means adapted to receive messages, said message comprising blocks of information bits; check indication means adapted to generate a check indication specifying the need for receiving some of said blocks of information bits; and control means

adapted to turning-off co-operating portions of said mobile station defining periods of full power saving where blocks of information bits are omitted, said periods of full power saving being separated by periods of normal power consumption where some of said blocks of information bits are received, wherein said control means is further adapted to replace at least some of said periods of normal power consumption by periods of reduced power consumption where at least one of said portions is off.

Hence, the mobile station according to the invention is adapted to reduce the power consumption in standby mode compared to the mobile stations of the prior art. Hereby, the frequency of battery charges and recharges can be reduced.

Preferably, said co-operating portions comprise a voltage-controlled oscillator, a loop-filter, and phase detector means being connected to form a phase-locked loop, and said phase detector means is adapted to be off during periods of reduced power consumption.

In accordance with a preferred embodiment, said phase detector means is adapted to provide a high-impedance output port when off.

In a preferred embodiment, said mobile station further comprises connection means with a first terminal connected to the output of said phase detector means, a second terminal connected to the input of said loop filter, and a control terminal connected to said control means, and said connection means is adapted to connect and to disconnect said phase detector means and said loop filter according to a control signal on said control terminal. By disconnecting said phase detector means and said loop filter during periods in which said phase detector means

is off, the current drain from said loop filter is reduced. Hereby, the power consumption of the mobile station is reduced.

In a particularly expedient embodiment, said connection means comprises a switch.

The present invention will now be described more fully with reference to the drawings, in which

Figure 1 illustrates the message word structure (MWS) of a transmit cycle according to the EIA-553 standard,

Figure 2 is a time chart illustrating that periods of full power saving alternate with periods of normal power consumption,

Figure 3 is a time chart illustrating a situation in which some periods of normal power consumption are replaced by periods of reduced power consumption according to the invention,

Figure 4A shows a block diagram of a part of a mobile station,

Figure 4B is a block diagram of a phase detector means, and

Figure 5 is a time chart illustrating the operation of a frequency generating part of a mobile station according to the invention.

Cellular mobile telephone systems comprise a network of base stations, each of which covers a particular geographical area or cell and communicates with the plurality of mobile or hand-portable phones (hereinafter "mo-

bile phones" or "mobile stations"). According to the prior art, such systems contain means to ensure to the highest degree that the nearest base station is used to communicate with each mobile phone, thus minimizing the transmitter power needed in the mobile phone.

In systems using the U.S. EIA-553 cellular standard, calling messages are transmitted to mobile phones in the standby mode by base stations in a format that includes five repeats of the 40-bit blocks. A calling message identifies a called mobile phone by including a so-called Mobile Identification Number (MIN) representing the telephone number in the message. Each message also contains a cyclic redundancy check (CRC) code, whose value depends on the data bits. The CRC code can be used to verify the correct decoding and even to correct single bit errors in the message. Due to the length of the MIN, it takes two calling messages to identify the phone uniquely, and the first calling message therefore includes continuation bits indicating that further information will follow. The latter of these two calling messages is called a continuation calling message.

Figure 1 shows the message word structure (MWS) of one transmit cycle according to the EIA-553 standard. Each transmit cycle, which is also called a control cycle, conveys five repeats A1, A2, ..., A5 of a first 40-bit word "A" and five repeats B1, B2, ..., B5 of a second 40-bit word "B". The A and B words belong to independent messages intended for mobile phones having odd and even mobile identification numbers (MIN), respectively.

The preamble bit-block labelled D, the so-called dotting sequence, is a 10-bit block of alternating 1's and 0's intended to provide the receiver with symbol resynchronization opportunities. Preceding the 10-bit dotting se-

quence is a single bit busy/idle flag, giving a total of 11 bits in the dotting sequence. Following the dotting sequence D is a bit-block labelled S. This bit-block includes an 11-bit sync word which is preceded by a busy/idle flag, making a total of 12 bits. Then there follow five repeats, each of two 40-bit calling messages designated A and B. Four extra busy/idle bits are inserted in each message repeat making 44-bit blocks. The total number of bits in a calling channel cycle is thus 1+10+1+11+2x5x(40+4)=463 bits. It is noted that the data bit-blocks A1, A2, ..., A5 contain redundant data, i.e. if no errors have occurred, these bit-blocks all contains the same data. Likewise, the bit-blocks B1, B2, ..., B5 contain redundant data.

When a mobile phone is in a standby mode, i.e. when it is neither originating nor receiving a call, it must listen to a base station for calls. The mobile phone consists of a number of parts, each part relating to a given function. During standby mode, the transmitter part of the phone needs only to be operative in short periods in order to keep in contact with the base station. In the remaining periods, the mobile phone does not transmit, and therefore the transmitter part of the phone do not have to be operative. Other parts of the phone have to be operative during standby mode, e.g. the receiver part. But, it is known that some parts can be operative in some periods while non-operative in other periods. The frequency generating part of the receiver in a mobile telephone is an example of a part that can be operative in some periods and non-operative in other periods, resulting in reduced power consumption compared to the situation where the part is constantly operative.

According to the prior art, Figure 2 illustrates that a part of a mobile telephone is operative in some periods

while non-operative in other periods. As shown, the periods in which the part is non-operative, the so-called periods of full power saving (PFPS), are mutually separated by periods in which the part is operative, the so-called periods of normal power consumption (PNPC). A part of the mobile phone normally includes a number of co-operating portions. During the periods of normal power consumption, the co-operating portions are operative (i.e. are on), while the co-operating portions are non-operative (i.e. are off) during the periods of full power saving.

The frequency generating part is an example of a part in a mobile station that can be operative in some periods (PNPC), in which blocks of information bits are received, and non-operative in other periods (PFPS), in which blocks of information bits are omitted. As mentioned, the message word structure (MWS) contains redundant blocks of data bits, as e.g. the contents of the bit-block A1 is repeated in the bit-blocks A2, ..., A5. According to the prior art, this fact is used to obtain reduced power consumption in e.g. mobile phones, as it is possible to omit some of the redundant data.

Figure 3 illustrates a situation in which some of the periods of normal power consumption (PNPC) are replaced by periods of reduced power consumption (PRPC) according to the invention. In the periods of reduced power consumption (PRPC) at least one of said co-operating portions is off, and hereby an additional reduction of the power consumption is obtained. The replacement of periods of normal power consumption (PNPC) with periods of reduced power consumption (PRPC) will be described in more details in the following.

Figure 4A illustrates the frequency generating part of a mobile station which e.g. can be used to tune a mobile

station into a desired channel. The frequency generating part, which is constructed as a phase locked loop (PLL), includes the following co-operating portions: a reference oscillator 1 (e.g. a voltage controllable crystal oscillator, VCXO), phase detector means 2, a loop filter 3, and a voltage controlled oscillator 4 (VCO).

The VCO 4 is an oscillator with an input and an output terminal. The VCO 4 is constructed to generate an oscillating signal on the output terminal, the oscillating signal having a frequency defined by the control voltage applied to the input terminal of the VCO 4. The input terminal of the VCO 4 is connected to an output terminal of the loop filter 3, and the output terminal of the VCO 4 is connected to a first input terminal of the phase detector means 2. The second input terminal of the phase detector means 2 is connected to the reference oscillator 1. The output terminal of the phase detector means 2 is connected to an input terminal of the loop filter 3 through a connection means 6. It is noted that the VCO 4 consumes power while operative, and it is therefore called an active portion in the following.

As described below, the connection means 6 is adapted to provide a high-impedance connection between the loop-filter 3 and the phase detector means 2 at least during periods of full power saving and periods of reduced power consumption. Likewise, a connection means can be inserted between the loop filter 3 and the VCO 4. It is noted that the connection means 6 can be implemented in many ways, e.g. as a relay or as a semiconductor switch. In a first embodiment the connection means 6 comprises a controllable switch. This will be described more fully below.

As illustrated in Figure 4B, the phase detector means 2 is often implemented as an integrated digital circuit, a

so-called PLL-chip 2, consisting of one or more programmable counters 13,14, a phase detector part 12, and a charge pump 11. The counters 13,14 are normally programmed by a micro controller. It is noted that the phase detector means 2, which is also called PLL-chip 2 in the following, is an active device consuming power while on. The loop filter 3 is usually a passive device, consisting of resistors and capacitors, which jointly with the characteristics of the VCO 4 and the charge pump 11 determine the behaviour of the phase locked loop (PLL). The frequency generated by the PLL (i.e. the VCO frequency) is determined by the values loaded into the programmable counters 13,14 and by the frequency of the reference oscillator 1.

The output from the phase detector 2 is a current which is proportional to the phase difference between the inputs. The loop filter 3 is either charged or discharged by this current, and the output voltage of the loop filter 3, which controls the VCO frequency, is constant when the phase difference is zero, i.e. no current is supplied. If a phase difference is detected at the input of the phase detector 2, the loop filter will either be charged or discharged depending on the design of the charge pump 11, and the loop filter voltage will either increase or decrease, respectively. Hence, if no current is supplied to the loop filter 3, the output voltage is kept constant.

When the PLL operates as described above, all the cooperating portions are on and the period is therefore a period of normal power consumption (PNPC). According to the prior art, a reduced power consumption is obtained by turning off the co-operating portions during so-called periods of full power saving (PFPS). In these periods, the phase detector means 2 and the VCO are turned off in

order to reduce the power consumption compared to the periods of normal power consumption (PNPC) where both the VCO 4 and the phase detector means 2 consume power. For example, it is possible to turn off the co-operating portions as redundant data blocks, which occur in the received data signal according to Figure 2, can be skipped.

In a preferred embodiment a check indication specifying the need for receiving some block of information is generated, i.e. specifying periods in which data shall be received. The check indications can be generated in several ways, e.g. generated with predetermined intervening periods, or generated when some given conditions in the mobile station are met. In the first situation in which the blocks of information bits that are going to be received are predetermined, e.g. only the first block of a number of blocks containing redundant data is received. In the latter case, the periods during which the blocks of information bits are going to be received depend on some given conditions in the mobile station, e.g. when an error has been detected in said blocks of received information bits, a block containing redundant information is also received. The detection can e.g. be based on majority voting but as this well known, it will not be described further in relation to this invention.

As mentioned previously, due to the length of the MIN, it takes two calling messages to identify the phone uniquely. This information can also be used in order to decide whether to replace periods of normal power consumption (PNPC) with periods of full power saving (PFPS): when the mobile phone has already identified from the first of the two calling messages of a message that the MIN does not match that of the receiving mobile phone, the mobile phone does not need to process the second calling message, the so-called continuation calling mes-

sage, and can power down for all five repeats of the second word.

According to the invention, additional reduction of the power consumption can be obtained by replacing some of the periods of normal power consumption (PNPC) with periods of reduced power consumption (PRPC), in which some of the co-operating portions are off, while others are still operating. Hereby a further reduction of the power drain is obtained in standby mode, and this can e.g. be achieved by omitting to turn all the co-operating portions on for every period of operation. In the embodiment shown, the PLL-chip 2 is the co-operation portion which is not turned on for every period of operation. In this case, the VCO is operating in the periods of reduced power consumption while the phase detector means is not operated. In other words, the periods of normal power consumption (PNPC) are substituted by periods of reduced power consumption (PRPC). Hereby a reduction of the power consumption is obtained as the power consumption during the periods of reduced power consumption (PRPC) is lower that the power consumption during the periods of normal power consumption (PNPC). The power saving is significant as a large number of periods typically can be replaced.

The reason why it is possible to substitute the some of the periods of normal power consumption with periods of reduced power consumption in this case shall be found in the following facts.

Firstly, the receiver does not need to tune to another channel during stand-by as long as the received signal strength is sufficient.

Secondly, the VCO 4 tunes to a frequency determined by the voltage on the control input. For one particular VCO

4 the relation between the control voltage and the output frequency is only affected by slowly changing parameters, such as temperature and humidity.

Thirdly, the current drain from the loop filter 3 into the control input of the VCO 4 is negligible as the input is very high impedance. It is noted that the control input normally includes a reverse biased diode (a varactor diode) and hence has a very high impedance.

Finally, the output of the PLL-chip 2 is a high-impedance port when powered down, or can be made a high-impedance port by use of a connection means 6, e.g. a switch in series between the output of the PLL-chip 2 and the input of the loop-filter. Therefore, only a small current is drained from the loop filter through the PLL-chip 2.

Taking these facts into account, it is clear that once the PLL has tuned the receiver to the appropriate channel, and the mobile station is in stand-by mode, the voltage on the control input only changes very slowly compared to the cycle time of the information received because of the very small leakage current involved. Thus, even when some periods of normal power consumption (PNPC) are substituted by periods of reduced power consumption (PRPC) in which the PLL-chip 2 is off, the VCO will still tune to the right channel (or very close to the right channel) due to the charge stored in the loop filter 3.

The phase detector means 2 is usually implemented as a chip which has either software-controlled (via a serial programming interface) or hardware-controlled (a pin) power down. The VCO 4 is usually turned off by switching off its power supply.

How often the PLL-chip 2 needs to be activated to ensure the leakage current or the environmental facts has not made the VCO 4 drift too far from the nominal frequency must be determined from case to case. In one embodiment, the periods of normal power consumption which have to be replaced by periods of reduced power consumption are predetermined, e.g. information about the current drain for the actual phase locked loop is used to predetermine the time interval between periods of normal power consumption in order to ensure that only acceptable frequency variations occurs in the VCO output signal.

In an other embodiment, the periods of normal power consumption which have to be replaced by periods of reduced power consumption are determined by use of automatic frequency control (AFC) means being able to give information about the difference between the VCO frequency and the frequency of the received signal. As described more fully below, the information from the AFC can therefore be used to determine when it is time to re-engage the phase detector means 2 after having been turned off.

The frequency generating part of a mobile station shown in Figure 4A further includes control means 8. The control means 8 includes an input port which is connected to a receiver part 9 of the mobile station. The receiver part 9 is connected to an antenna 10, and is also connected to the output terminal of the voltage controlled oscillator 4. As known in the prior art, the receiver part 9 is adapted to receive information from the antenna 10 using the VCO as a local oscillator.

The control means 8 further comprises output ports which are used to control the power-on and power-off of different co-operating portions in the mobile station and hereby defining the periods of full power saving (PFPS),

the periods of normal power consumption (PNPC), and the periods of reduced power consumption (PRPC). As shown in Figure 4A, a first output port is connected to the VCO 4 and a second output port is connected to the phase detector means 2. By use of the output ports, the control means 8 provides the VCO 4 and the phase detector means 2 with the control signal VCO_{PW} and PLL_{PW}, respectively.

The connection means 6 is connected to a third output port of the control means 8, and is hereby controlled by the control signal CON_{PWR}, which e.g. equals the control signal PLL_{PWR}, and hereby making the connection the phase detector means 2 and the loop filter 3 a high-impedance connection during periods in which the phase detector means 2 is off.

The input port of the control means 8 is adapted to receive frequency information from the receiver part 9 of the mobile station. The frequency information includes information about the frequency of the VCO 4 and the frequency of the received signal. By use of this information, the AFC, which may be included in the control means 8, determines the drift of the VCO frequency in relation to the frequency of the received signal. As described in the following, the frequency drift information is used differently during periods of normal power consumption (PNPC) and during periods of reduced power consumption (PRPC).

As shown in the figure, the control means 8 also includes a control terminal which is connected to the reference oscillator 1. Therefore, the output frequency of the reference oscillator 1 can be controlled by the control means 8. During periods of normal power consumption (PNPC), the phase locked loop is operated normally, and the frequency of the VCO 4 is therefore continuously be-

ing regulated to be locked to the signal of the reference oscillator 1. When the AFC detects a frequency drift between the VCO and the received signal, the reference oscillator 1 is regulated and hence the frequency of the VCO 4 is regulated.

During periods of reduced power consumption (PRPC) the frequency drift information can be used to supervise the replacement of succeeding periods of normal power consumption (PNPC) with periods of reduced power consumption (PRPC). This is a fact, as the frequency drift information tells whether the PLL-chip is to be turned on, i.e. turn on the phase locked loop in order regulate the VCO frequency during a period of normal power consumption, in the following periods or not.

It is noted that, the current drain of a PLL-chip 2 typically is in the order of 2-10 mA when the PLL-chip 2 is on, while typically in the order of 1-100 µA when off. The current drain of a VCO is typically 5 mA when on, while no current drain occurs when off. This fact illustrates that reduced power consumption can be achieved by replacing periods of normal power consumption (PNPC) with periods of full power saving (PFPS), and that additional reduction of the power consumption can be achieved by replacing periods of normal power consumption (PNPC) with periods of full power saving (PFPS).

It should be noted that the VCO can be brought into the desired oscillating stated significantly faster than the entire phase locked loop can be brought into lock. Hereby additional reduction of the power consumption is achieved compared to the prior art. Typically a large number of PNPC is replaced by PRPC and hereby a significant reduction of the power consumption is obtained. This can be illustrated by the fact that the duration of a control

channel cycle is 46.3 ms but by replacing a number of periods of normal power consumption (PNPC) by periods of reduced power consumption (PRPC) according to the invention a mutual intersection between periods of normal power consumption of 1.0 s or even more can typically be obtained.

Figure 5 illustrates the operation of a frequency generating part of a mobile station according to the invention. The uppermost line of the figure illustrates a section of a received signal, i.e. a number of succeeding transmit cycles having the message word structure (MSW) shown in Figure 1.

The control means 8 produces a VCO on/off signal and a PLL-chip on/off signal. In the figure, these signals are called VCO_{PW} and PLL_{PW}, respectively. Attention will be directed to lines two through five in Figure 5 illustrating the power-on and power-off of the VCO 4 and the phase detector means 2 according to two embodiments of the invention.

According to the invention, a number of the periods of normal power consumption are replaced by periods of reduced power consumption. Periods of full power saving (PFPS) are inserted between the periods of normal power consumption (PNPC). By observing the interval shown in the figure from the left to the right, it can be seen that the VCO 4 and the phase detector means 2 start by being off (i.e. powered down) defining a period of full power saving (PFPS), in which the blocks of information bits are omitted.

In lines 2 and 3, showing a time chart related to a first embodiment of the invention, the period of full power saving is followed by a period in which both the VCO 4

and the phase detector means 2 are on. The period indicated by t2, in which blocks of information bits are received, is therefore a period of normal power consumption (PNPC).

In the following period, a period of full power saving (PFPS), the blocks of information bits are omitted as both the phase detector 2 and the VCO 4 are turned off. This period is followed by a period indicated by t3 in the figure. The VCO 4 is turned on while the phase detector means 2 is off. Thus, compared to the prior art, the period of normal power consumption (PNPC) is replaced by a period in which at least one of the co-operating portions is off. In this case, the phase detector means 2 is the co-operating portion being off. The period indicated by t3 in the figure is therefore a period of reduced power consumption (PRPC). Compared to the prior art, a reduced power consumption is obtained.

The following period is a period of full power saving (PFPS) which is followed by a period of normal power consumption (PNPC). It is noted, that the period of normal power consumption (PNPC) could also have been a period of reduced power consumption (PRPC) if the frequency of the VCO output signal is still acceptable, i.e. the frequency has only changed within a acceptable frequency interval.

It is further noted that in the periods of normal power consumption (PNPC) the phase locked loop is activated for a period prior to the actual use of the output frequency of the VCO 4 in order to receive data. This period, which is indicated by t1 in the figure, is used to lock the phase locked loop to the reference signal, i.e. bring the VCO 4 into a desired oscillation state. The period t1 is a period of full power consumption and a reduction of the power consumption is obtained according to the invention

as operation of the VCO 4 prior to actual use in the periods of reduced power consumption (PRPC) is significantly smaller than t1 and is therefore not shown in the figure.

Lines 4 and 5 show a time chart related to a second embodiment of the invention. As it can be seen, the period of normal power consumption (PNPC) starts when both the VCO 4 and the phase detector means 2 are turned on. But, compared to the first embodiment, the phase detector means 2 is turned off prior to the end of said period of normal power consumption (PNPC). Hereby, an additional power saving is obtained. It is noted that both the phase detector means 2 and the VCO 4 are on in the period indicated by t4 in the figure, and the phase locked loop is operated normally. In the period t4 the phase locked loop is regulating the output frequency of the VCO 4 to be locked to the frequency of the reference oscillator 1. Therefore, the period t4 is preferably defined as being sufficient to perform the desired regulation, but not longer than necessary in order to save power. The frequency of the output signal from the VCO 4 can be maintained during periods of reduced power consumption.

Although a preferred embodiment of the present invention has been described and shown, the invention is not restricted to it. It may also be embodied in other ways within the subject-matter defined in the following claims. For example, the decision whether to replace a given period of normal power consumption (PNPC) with a period of reduced power consumption (PRPC) can be based on the detection of errors in the received data blocks using the above-mentioned cyclic redundancy check (CRC) codes. Hereby, errors which could occur as a result of vibrations of the mobile phone influencing the output frequency of the VCO can be avoided.

Patent Claims:

1. In a radio communications system having at least one base station serving one or more mobile stations, a method of reducing standby power consumption of said mobile stations, said method comprising the steps of:

receiving messages in a mobile station from said at least one base station, said message comprising blocks of information bits;

generating a check indication specifying the need for receiving some of said blocks of information bits; and

turning-off co-operating portions of said mobile station defining periods of full power saving where blocks of information bits are omitted, said periods of full power saving being separated by periods of normal power consumption where some of said blocks of information bits are received, characterised in that

at least some of said periods of normal power consumption are replaced by periods of reduced power consumption where at least one of said portions is off.

2. A method according to claim 1, characterised in that said omitted blocks of information bits are redundant blocks of information.

3. A method according to claim 1, characterised in that said omitted blocks of information bits are blocks related to previously received blocks, said previously received blocks having been found to be irrelevant.

4. A method according to one or more of claims 1-3, characterised in that a number of succeeding check indications are generated with predetermined intervening periods.

5. A method according to one or more of claims 1-4, characterised in that said check indication is generated when an error has been detected in said blocks of received information bits.

6. A method according to one or more of the preceding claims, characterised in that said co-operating portions include a voltage-controlled oscillator (4), a loop-filter (3), and phase detector means (2), where said voltage-controlled oscillator (4), said loop-filter (3), and said phase detector means (2) being connected to form a phase-locked loop, and said phase detector means (2) is turned off in said periods of reduced power consumption.

7. A method according to claim 6, characterised in that said phase detector means (2) is turned off prior to the end of said period of normal power consumption.

8. A method according to claim 6 or 7, characterised in that said phase detector means (2) is operated to have a high-impedance output port when said phase detector means (2) is off.

9. A method according to claim 6 or 7, characterised in that a switch is operated in order to disconnect said loop-filter from the phase detector means (2) when said phase detector means (2) is off.

10. A method according to one or more of claims 1-9 characterised in that the periods of normal power consumption to be replaced by periods of reduced power consumption are predetermined.

11. A method according to one or more of claims 1-10 characterised in that the periods of normal power consumption to be replaced by periods of reduced power consumption are determined by use of an automatic frequency control.

12. A mobile station adapted to be used in a radio communications system, said mobile station comprising:

receiver means adapted to receive messages, said message comprising blocks of information bits;

check indication means adapted to generate a check indication specifying the need for receiving some of said blocks of information bits; and

control means (8) adapted to turning-off co-operating portions of said mobile station defining periods of full power saving where blocks of information bits are omitted, said periods of full power saving being separated by periods of normal power consumption where some of said blocks of information bits are received, characterised in that

said control means (8) is further adapted to replace at least some of said periods of normal power consumption by periods of reduced power consumption where at least one of said portions is off.

13. A mobile station according claim 12, characterised in that said co-operating portions com-

prise a voltage-controlled oscillator (4), a loop-filter (3), and phase detector means (2) being connected to form a phase-locked loop, and that said phase detector means (2) is adapted to be off during periods of reduced power consumption.

14. A mobile station according to claim 13, c h a r a c t e r i s e d in that said phase detector means (2) is adapted to provide a high-impedance output port when off.

15. A mobile station according to claim 13, c h a r a c t e r i s e d in that said mobile station further comprises connection means (6) with a first terminal connected to the output of said phase detector means (2), a second terminal connected to the input of said loop filter (3), and a control terminal connected to said control means (8), and that said connection means is adapted to connect and to disconnect said phase detector means (2) and said loop filter (3) according to a control signal on said control terminal.

16. A mobile station according to claim 15, c h a r a c t e r i s e d in that said connection means (6) comprises a switch.

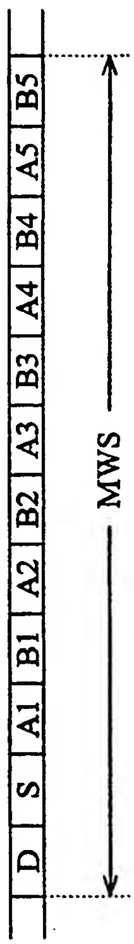

FIG. 1

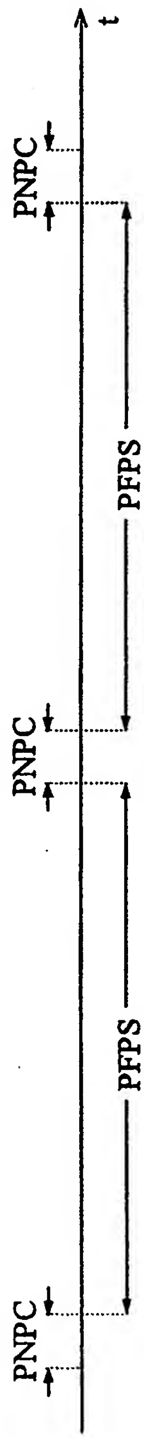

FIG. 2

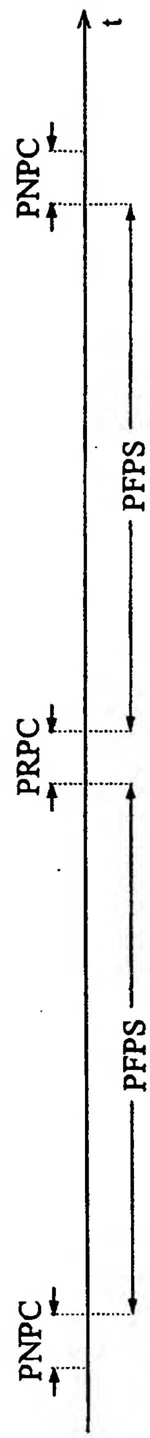

FIG. 3

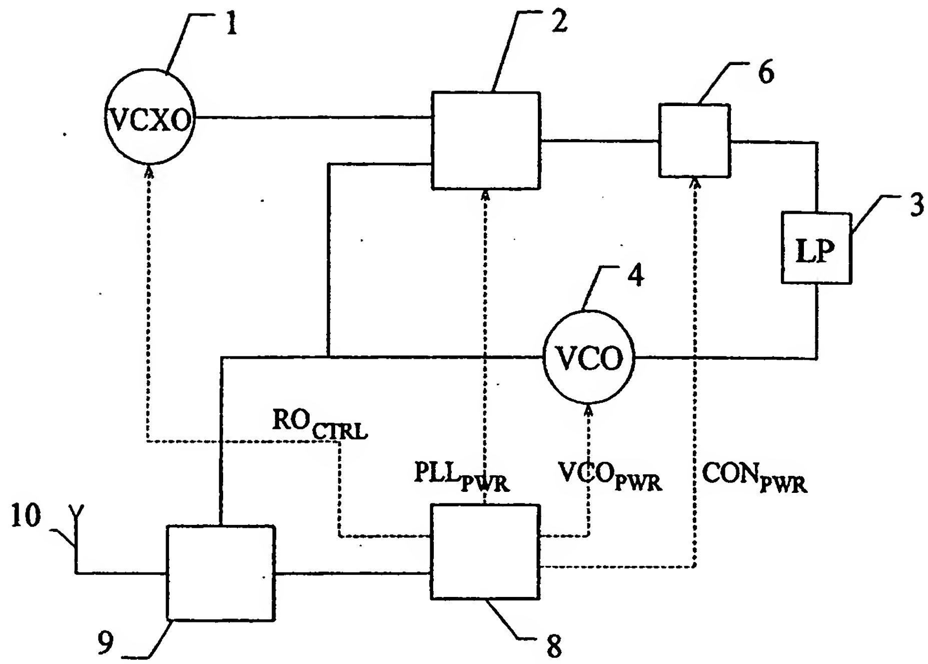
1
2
6
3
VCXO
LP
4
VCO
RO CTRL
PLL PWR
VCO PWR
CON PWR
10
9
8

FIG. 4A

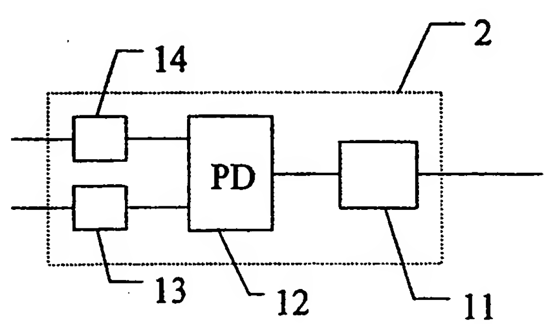
2
14
PD
13
12
11

FIG. 4B

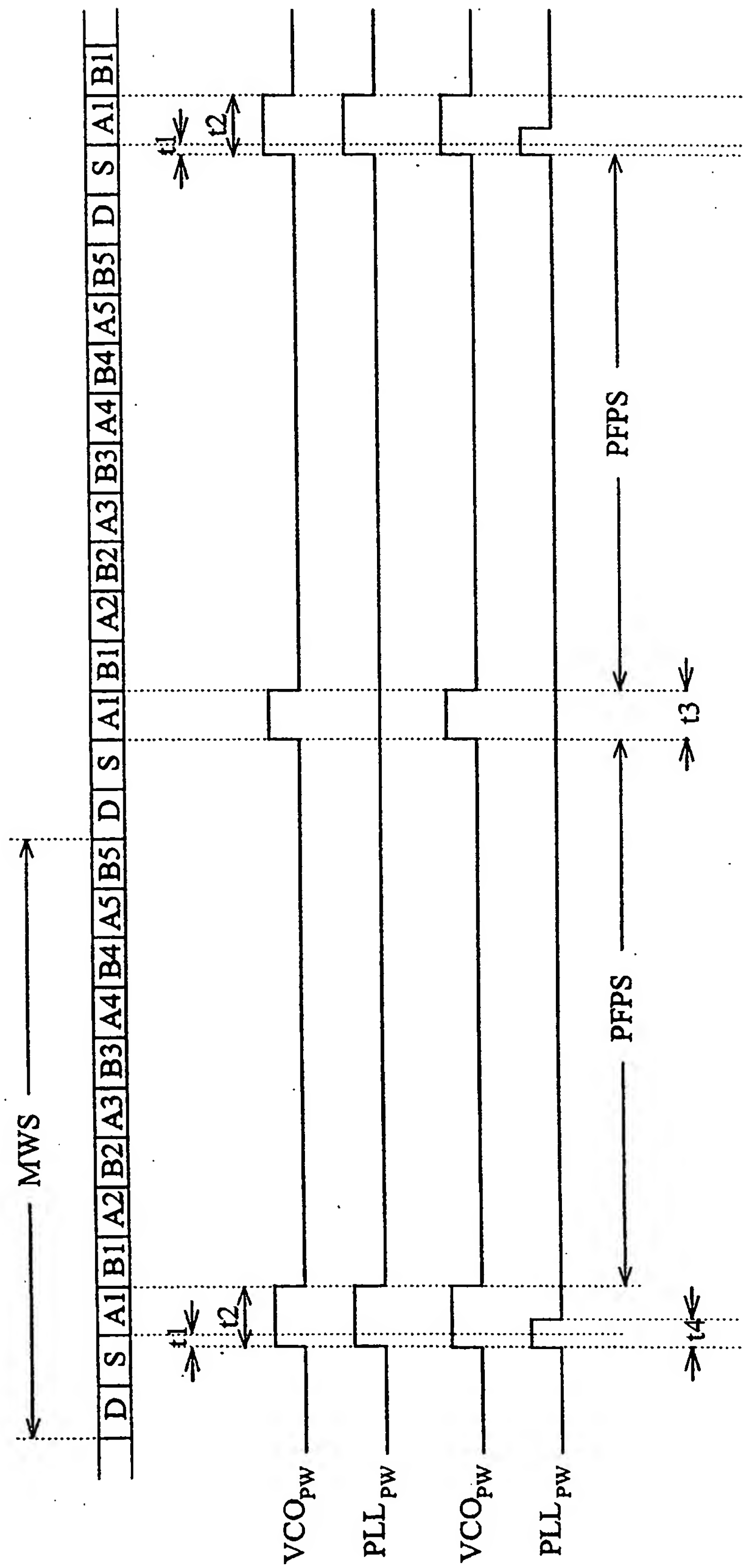
D S A1 B1 A2 B2 A3 B3 A4 B4 A5 B5 D S A1 B1 A2 B2 A3 B3 A4 B4 A5 B5 D S A1 B1
MWS
PFPS
PFPS
t1
t2
t3
t4
t1
t2
VCO_{PW}
PLL_{PW}
VCO_{PW}
PLL_{PW}

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/02215

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04Q 7/32
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5568513 A (THOMAS M. CROFT ET AL), 22 October 1996 (22.10.96), column 4, line 32 - line 53; column 6, line 57 - column 7, line 27 --	1-5,10-12
A	WO 9704532 A1 (ERICSSON INC.), 6 February 1997 (06.02.97), page 6, line 15 - page 7, line 23; page 10, line 19 - page 11, line 27 --	1-5,10-12
A	EP 0473465 A1 (AUDIOVOX CORPORATION), 4 March 1992 (04.03.92), column 3, line 28 - line 49 --	1-5,12

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 March 2000	19 -04- 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Jaana Raivio/cs Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/02215

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0656693 A2 (NOKIA MOBILE PHONES LTD.), 7 June 1995 (07.06.95), page 4, line 33 - line 46, abstract --	1,12
A	US 5402446 A (YOICHIRO MINAMI), 28 March 1995 (28.03.95), abstract -- --------	1,12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SE 99/02215

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				CN	1040932	B	25/11/98
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				DK	2695	A	10/01/95
				FI	950110	A	10/01/95
				GB	2283643	A,B	10/05/95
				GB	9500614	D	00/00/00
				HK	1006627	A	00/00/00
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				IT	MI940927	D	00/00/00
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				SE	9404586	A	27/02/95
				SG	45279	A	16/01/98
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				BR	9609496	A	02/03/99
				CN	1195433	A	07/10/98
				EP	0839411	A	06/05/98
				JP	11509395	T	17/08/99
				US	5794137	A	11/08/98
EP	0473465	A1	04/03/92	SE	0473465	T3	
				CA	2043118	A	28/02/92
				FI	912298	A	28/02/92
				JP	5095315	A	16/04/93
				US	5224152	A	29/06/93
EP	0656693	A2	07/06/95	BR	9404675	A	25/07/95
				CN	1111886	A	15/11/95
				US	5471655	A	28/11/95
US	5402446	A	28/03/95	CA	2106140	A,C	18/03/94
				GB	2271230	A,B	06/04/94
				JP	6104941	A	15/04/94
				KR	9607809	B	12/06/96